

Coherent light scattering by molecular vibrations

Alexei V. Sokolov

*Institute for Quantum Science and Engineering and Department of Physics and Astronomy, Texas A&M University, College Station, TX 77843; and Baylor University, Waco, TX 76798, USA
(sokol@physics.tamu.edu)*

Atomic or molecular coherence is the central feature of multiple techniques; high degree of coherence can lead to astonishing results. The term “coherence” refers to a situation when all molecules/atoms in a macroscopic sample oscillate in unison, or, in the language of quantum mechanics, to a situation where a molecular/atomic ensemble is prepared in a vibrational superposition state. Atomic coherence has earlier been used in electromagnetically induced transparency, ultraslow light propagation, and lasing without inversion. Increased and cleverly manipulated molecular coherence has found important applications in coherent Raman spectroscopic detection and sensing [1]. Coherence yields the famous N^2 signal enhancement, compared to spontaneous Raman spectroscopy. Another remarkable example of an application of molecular coherence is a technique termed molecular modulation, which allows ultrafast laser pulse shaping and non-sinusoidal field synthesis via broadband (multi-sideband) coherent Raman generation [2]. An additional dimension to the laser field engineering is added, within the molecular modulation technique, by using spatial light modulators to shape the transverse beam profiles, taking us toward production of space- and time-tailored sub-cycle optical fields – possibly coupled to plasmonic nano-antennas for single-molecule spectroscopy with nano-structured light. These ideas open intriguing opportunities for molecular spectroscopic studies [3–5].

References

- [1] M. O. Scully *et al.*, FAST CARS: Engineering a laser spectroscopic technique for rapid identification of bacterial spores. *Proc. Natl. Acad. Sci. USA* **99**, 10994 (2002).
- [2] A. V. Sokolov *et al.*, Generation and control of femtosecond pulses by molecular modulation. *J. Mod. Opt.* **52**, 285 (2005).
- [3] D. Pestov *et al.*, Optimizing laser-pulse configuration for coherent Raman spectroscopy. *Science* **316**, 265 (2007).
- [4] P. R. Hemmer *et al.*, Standoff spectroscopy via remote generation of a backward-propagating laser beam. *Proc. Natl. Acad. Sci. USA* **108**, 3130 (2011).
- [5] D. V. Voronine *et al.*, The dawn of quantum biophotonics. In *Optics in Our Time*, edited by M. D. Al-Amri, M. El-Gomatiand, and M. S. Zubairy (Elsevier, Amsterdam, 2016).